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ABSTRACT

Students who are anxious about mathematics elect to take fewer mathematics courses in high school and college. This math avoidance is also typical for many first-year elementary school teachers who show high levels of mathematics anxiety. These teachers schedule less time for mathematics instruction than their less anxious colleagues. This paper reports on preservice teachers' affective responses to computers as a medium for learning and understanding mathematics. Three main themes emerged from the students' responses: (1) the computer in relation to their status as learners; (2) the computer in relation to their status as future teachers; and (3) the computer as a medium for communication. Overall, the incorporation of computer activities into mathematics content courses, in addition to lectures and manipulative labs, was a positive experience for the preservice teachers as well as for the instructors. The computer activities helped students develop a deeper understanding of the mathematical concepts taught, which was the primary goal for introducing the computers. The computer sessions contributed to a more relaxed classroom atmosphere and served as an incentive for more consistent class attendance for some students. The ease of electronic communication also led to extended and more personal teacher-student interactions. (PVD)

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Pre-Service Elementary Teachers' Affective Responses to Computer Activities in Mathematics Content Courses

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Pre-Service Teachers' Affective Responses to Computer Activities in Mathematics Content Courses

We are having fun playing.
Tina, MAT II, Spring 95

Tina[1] made the comment about "having fun" and "playing" during an exploratory lesson on spreadsheets as the teacher approached her and her partner to check on their progress. But, "we are having fun playing," was only half of Tina's remark. The other half referred to the class she was attending: "I don't believe I said that in math class!" Apparently, having fun and playing were not part of Tina's expectations for a math class. Tina's reservation toward mathematics, reflected in the second part of her comment, is shared by many students. In particular, many pre-service elementary teachers enter mathematics content classes with apprehension and often with anxiety, that is, "scared, nervous, and sick to my stomach" (Deedee, MAT II, Fall 94). Such negative feelings toward mathematics are not limited to students who struggle in their mathematics classes. Students who appear successful in mathematics, that is, students who are able to take advanced algebra, trigonometry, or even college calculus, often approach mathematics with reservations and anxiety (Tobias, 1991). Math anxiety often leads to math avoidance which in turn can have a negative impact on performance (Trice & Ogden, 1986/87).

Math anxious students elect to take fewer mathematics courses in high school and in college, and the content of the courses selected is often less sophisticated (Trice & Ogden, 1986/87). This math avoidance is also typical for many first-year elementary school teachers who show high levels of mathematics anxiety. These teachers schedule less time for mathematics instruction than their less anxious colleagues. In addition, only about 63 % of the time scheduled for mathematics instruction is actually spent on mathematics (Trice & Ogden, 1986/87). Therefore, elementary teachers with high levels of math anxiety may unwillingly deprive their students of necessary elementary mathematics experiences and consequently prepare the ground for continued math anxiety and avoidance in their own students.

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[1] All names are pseudonyms.

Pre-Service Teachers' Affective Responses to Computer Activities in Mathematics Content Courses

As mathematics educators, we strive to ease pre-service elementary teachers' anxiety by introducing them to more concrete ways of viewing and learning mathematics. For that reason, activities with manipulatives play a prominent role in our teaching. Starting in the fall of 1994, we also made activities on computers an integral part of the mathematics content courses. Computer activities are similar to activities with manipulatives in that they help students visualize mathematical concepts; therefore, they are more concrete than number sentences or formulas. On the other hand, manipulating objects on a computer screen is more abstract than physically moving and counting objects like blocks or beans. Objects on a computer screen can be considered a bridge between concrete manipulatives and abstract symbols (Abramovich, 1995).

In addition, computers provide many opportunities for exploration. They are ideal for trial-and-error approaches and for backtracking and correcting mistakes. In particular, the *Undo* feature common to many software programs allows students to be more daring in their explorations: they can make mistakes without consequences. On the other hand, a lack of familiarity with computers and software programs, unexpected computer crashes, and computer anxiety in general can increase the pre-service teachers' level of anxiety in a math class. Computer anxiety and math anxiety appear to be related (Gressard & Loyd, 1987; Fariña, Arce, Sobral, & Carames, 1991; Maurer, 1994; Weil, Rosen, & Wugalter, 1990). To some extent, this relationship may be due to the fact that computers are often housed in mathematics departments and negative feelings toward mathematics may be extended to computers (Gressard & Loyd, 1987). Computer attitudes have also been found to be affected by computer experience (Gressard & Loyd, 1987). The more computer experience students have the less anxious and more confident they tend to be. In the mathematics courses described in this paper, we felt that the benefits computers offer for mathematical experimentation and learning would outweigh the added stress some students might experience.

Our integration of mathematical computer activities evolved over three quarters and was the result of several factors. First, our access to technology increased from occasional visits to a computer lab to teaching in a computer enhanced classroom. Second, as we worked with the

computers ourselves and prepared lessons, we gained a fuller appreciation of the functions of various software programs and the potential of the computer network. Finally, we ourselves were learning about alternate ways of perceiving mathematics as we received responses from our students. The students' feedback helped us to modify our teaching and to expand our repertoire.

In this paper, we are reporting on pre-service teachers' affective responses to computers as a medium for learning and understanding mathematics. Three main themes emerged from the students' responses: (1) the computer in relation to their status as learners, (2) the computer in relation to their status as future teachers, and (3) the computer as a medium for communication.

METHOD

Data Collection

During the academic year 1994/95, data were collected from six groups of pre-service elementary teachers. Each group consisted of approximately 35 students enrolled in one of the two mandatory mathematics content courses at a university in the south-eastern United States. The first content course, Mathematics for Elementary Teachers I (MAT I), introduces problem solving, number theory, set theory, and basic operations with whole numbers, decimals and fractions. In Mathematics for Elementary Teachers II (MAT II), the focus is on statistics, probability, geometry, and measurement. The classes met daily for 50 minutes during 10-week academic quarters, with the authors serving as instructors.

The computer experiences took place in a Macintosh lab and in the *enhanced classroom* associated with the university's mathematics education department. The enhanced classroom (Figure 1) features 16 Power Macintosh computers, a server (the teacher's computer) with overhead display panel, a printer, and six large tables, each with room for six students. Lectures, manipulative labs, and computer activities can be easily integrated into one lesson in the enhanced classroom. In contrast, a teaching arrangement that has to alternate between a regular classroom and a computer facility necessarily leads to a more obvious division between classroom and computer experiences. All computers, whether in the enhanced classroom, in the computer labs,

or in mathematics education offices, are connected to the university network. This feature allowes students access to the server as well as to selected files in the instructors' personal workstations.

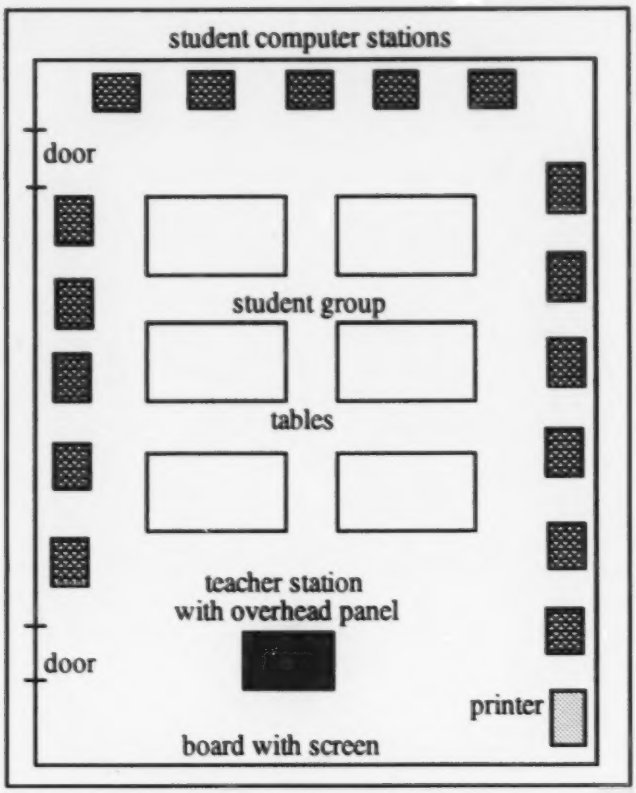

Figure 1. The enhanced classroom.

Data Sources

The data sources from the three groups of MAT I students consisted of pre-course surveys and topic-specific essays. Although the essays were not graded for content, students were required to complete them in order to get full credit for the class. For the first assignment, students were asked to write about problem solving and specifically how they felt when a problem looked impossible or when their struggles yielded a solution. For the second essay, the students were asked to reflect on their exploration of number bases other than Base 10. Finally, the students were asked to write an essay on their attitudes and beliefs about mathematics and the integration of computer activities into the mathematics content course.

The data sources from the three groups of MAT II students consisted of one essay, weekly reflections from all students, and anecdotal comments collected during computer labs. The essay was assigned at the beginning of the quarter. The students were asked to write about their personal mathematics history from elementary school to college. For the weekly reflections, students were encouraged to comment on any issue important to them, such as the pace of instruction, the topics covered, the classroom activities, the amount and nature of the homework assignments, the tests, specific classroom events, or personal problems. Neither the essay nor the weekly reflections were graded for content, but the students received credit for turning in the assignments.

Computer Software

Two interactive microworlds, TOYS and TIMA:BARS[2], were introduced in MAT I. These two programs lend themselves particularly well to some of the topics in Mathematics for Elementary Teachers I. TOYS features small geometric shapes that can be placed into the workspace and then moved around. The shapes can be grouped into strings, and the strings can be grouped into two-dimensional chains. All objects, that is, shapes, strings, and chains, can be reproduced with ease. TOYS permits exploration of basic arithmetic operations involving regrouping and borrowing and can be used to examine different number bases. TIMA:BARS, which is often used for exploration of fractional relationships, allows the student to create arbitrary rectangular "units" which can be copied, divided into pieces of equal size, or glued together. With TIMA:BARS, it easy to create a bar which is, for example, 4/5 of a given unit bar.

In the three MAT II courses, the following software programs were introduced: the spreadsheet Excel during the statistics unit, the Chance microworld (developed by a graduate of the mathematics education department) during the probability unit, and LOGO and The Geometer's Sketchpad during the geometry and measurement units. In addition, electronic mail accounts were available to all students and mandatory for the MAT II for students in the winter and spring quarters of 1995. All students in both courses received instruction how to use the network.

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[2] The development of Toys and TIMA:Bars was supported by NSF Grant No. RED-8954678 (principal investigators L. P. Steffe and J. Olive).

Data Analysis

The data were analyzed using analytic induction. Analytic induction involves "scanning the data for categories of phenomena and for relationships among such categories, developing typologies and hypotheses upon an examination of initial cases, then modifying and refining them on the basis of subsequent cases" (LeCompte, Preissle, & Tesch, 1993, p. 254). In a first step, all computer-related comments in the essays and reflections were color-coded according to whether they reflected a positive or negative attitude toward the computer activities. Second, the comments were labeled with short identifiers indicating the context to which they referred (e.g., e-mail, work with partners), the attitude toward the computer activity they expressed (e.g., skeptical, feeling successful, positive but confused), or some uses of the computer (e.g., makes life easier, makes concepts visual). Third, the comments were grouped into three broad categories: (1) comments referring to the present state of the pre-service teachers as learners, (2) comments referring to their future state as teachers, and (3) comments referring to teacher-student communication. Finally, the emerging groups and categories were refined and the comments reorganized.

RESULTS

In general, the pre-service teachers' affective responses to the integration of computer activities into their mathematics courses were positive. The students were grateful for the opportunity to become familiar with or learn more about computers and different software programs. They were aware that they needed to be at least computer literate if they wanted to be abreast of current trends in education, and they hoped that extended experience would help them overcome their initial insecurity: "I don't have much experience with [computers]. They can be intimidating. I hope that by the end of the quarter I will feel comfortable enough to take a test on it" (Cara, MAT II, Spring 95).

The overall positive attitude toward the computer activities were reflected in the students' comments. Many wrote that they "liked working with the computers," that they "enjoyed the computers," or that "computers were fun." More important to us than the expression of a general positive attitude toward the inclusion of computers, however, were comments that dealt with some

specific aspect of the course. We first present those responses that address the computer experiences in relation to the pre-service teachers' experiences as learners in a mathematics course. We then describe comments that pertained to the role of computers in their future careers as teachers. Finally, we elaborate on the effect of electronic communication on the relationship between instructors and students.

Computers in the Pre-Service Teachers' Mathematics Instruction

As participants and learners in a mathematics course, pre-service teachers commented on the computer experiences with respect to three aspects: the way computers helped them learn mathematical concepts, the way the computer activities affected their feeling of well-being in the class, and the way students thought about the computer activities in relation to assessment.

Learning mathematical concepts. Our primary reason for introducing the computer into the mathematics course was to use it as a tool for learning mathematical concepts. In order for our students to become successful teachers of elementary school mathematics, they needed to gain a deeper understanding of the concepts they will be required to teach.

One of these basic concepts, for example, is our number system structured around place-value and base 10. Students, having grown up using this number system without reflecting on it, need to be able to step back and analyze its properties in order to develop appropriate teaching strategies for their students. One way to help students gain an understanding of the basic properties of the Base-10 system is to require them to learn to count and compute in Base 12, a system in which 12 ones are grouped into units of one dozen, and 12 dozens are grouped into units of one gross, or 144.

We encouraged our students to use the Toys microworld to help them visualize groupings of objects. Recall that Toys permits students to string objects together and then to chain strings of objects together. Thus, it was easy to model the different units in Base 12 by chains, strings, and single toys. Anne (MAT I, Spring 95) reported, "I personally was able to grasp other number bases easier from [sic] using the Toys program." Matthew (MAT I, Spring 95) said, "For the most part, working on the computers made things that I couldn't see in my mind visible to me for

better understanding. . . . Computations in Base 12 would have been impossible if not for these machines." Because the images on the computer can be seen, students are better able to visualize the mathematics they are attempting to understand. Mary (MAT I, Spring 95), seemed to be reflecting on her own experiences with fractions and the microworld TIMA:BARS when she wrote about teaching future students:

> They [computer microworlds] make it possible to change printed words into visual representations that make a problem seem more real. Colors, shapes, and amounts can be controlled by the student. This makes [the student] feel more like an active participant than a spectator. It also allows them to create and use their imaginations. A student who is having trouble understanding why 5 3/4 + 2 1/2 = 8 1/4 can use the explorations on the computer to create colorful shapes to visually represent the fractions. Not only does the student now know the answer and how they got it, but they also [have] created an image of their own that they will retain in their memory. I feel that the more students are allowed to use computers in the classroom, the more they will learn.

Another student, Julie (MAT I, Spring 95), said that, "I liked the Timabars program a lot because it helped me see how to divide and add fractions and what the new pieces will look like. I think that having used the program helped me on the test." Angie (MAT I, Winter 95) said, "Then when we began using the computer programs, such a TimaBars, it gave an entire new meaning to math. To be actually able to see what 1/12 looked like was pretty neat." Sharon (MAT I, Spring 95) said she was able to "create a good representative picture of 2/3 x 3/5 without having to spend a lot of time drawing with a ruler and measuring. Using TIMA:Bars is a creative way of learning math concepts."

Nina (MAT I, Spring 95), reflecting on her experiences as a student, described how she would teach her students how to divide 3 by one-half:

> Kids aren't passively watching the teacher put 3 divided by 1/2 equals 6 . . . on the board. With computers they are able to construct 3 pieces and cut them in to 1/2 pieces to show that it equals 6. Using computers makes concepts easier to grasp because they can see how and why

the multiplication or addition of fractions works and not just memorize how to do the operations.

The pre-service teachers' responses indicate that they felt they were able to develop a more profound understanding of the concepts they would have to teach. They expressed an appreciation for the computer's potential to help them visualize the abstract mathematical concepts and operations.

Classroom atmosphere. When students enter the mathematics content classes, they often arrive with a sense of unease. They do not know their classmates or the teacher, nor do they know what to expect from the course. Consequently, the classroom atmosphere at the beginning of the quarter is often tense. The students prefer to sit, listen, and take notes. Early on, the working arrangement during computer sessions contributed significantly to a more relaxed classroom atmosphere. As soon as pairs of students began to work at the computers, they began to communicate with each other. Students with computer experience explained and demonstrated elementary computer functions to their less experienced classmates. Some students read the teacher's step-by-step instructions while their partners executed the moves on the computer. Several students made comments about how much they enjoyed the work with a partner. For example, Staci (MAT II, Winter 95) said, "I like working with someone else on the computer. That way it is easier to work out problems." Josie (MAT II, Winter 95) appreciated that she had the opportunity to learn from her partner: "I really like the computer work and [the fact] that my partner, Beatrice, has a lot of experience with computers. I have learned from her." Independence, choice of activities, and opportunity to work at their own pace were other positive aspects of the computer labs. But most importantly, the computer labs encouraged the students to work by trial-and-error and to explore on their own. Susan (MAT II, Winter 95), in her first reflection, summarized these positive aspects:

I really enjoyed the sessions with the computer. I thought the Excel handout you put together was great. It answers basic questions and allows us to work more independently. I believe

the best way to become familiar with a computer application is to experiment and play with it so I like the way the computer sessions are organized.

Students also reacted positively to the challenge the computers presented to them, even if this challenge included some anxiety: "Learning to use the Excel program made me feel successful. Computers make me nervous but hopefully with this class I will feel more comfortable" (Doris, MAT II, Winter 95). Amy's (MAT II, Winter 95) comment reflects on that challenge and the way she was dealing with it: "This week was a little more challenging than the first week. I liked that because I figured out a lot on the computer myself that I wouldn't have really understood unless I was piddling around."

Students saw the computer labs as welcome change to the usual textbook-based mathematics lessons they had experienced in school: "I also think that the computers added a new dimension to our plain old boring textbook work" (Doris, MAT II, Spring 95) For some students, the computer labs were an incentive to come to class because they were looking forward to the experience. Jennifer (MAT II, Spring 95) summarized her feelings as follows, "I think the computers helped me enjoy the class more. I love to work on computers and knowing that a day or two a week would be spent on computers was an incentive to come to class."

Assessment. There were, however, some trade-offs to our incorporation of computers into the teaching of mathematics content. Because we anticipated that learning to use the computer might add to the stress of learning the mathematics content, we did not include mandatory computer items in the tests or the final. This decision had unforeseen consequences for the students' attitudes toward the computer labs. As test times came close, several students suggested omitting the labs and practicing more book problems similar to test questions. From the point of view of the instructor, the students' focus on grades overshadowed their learning opportunities. The students' test anxiety and the conflict between learning math and working for a grade were most aptly verbalized by Mandy and Andrea, both students who completed the course with good grades:

> I feel that we are spending too much time on the computers, and not enough time going over old homework and new material. Don't get me wrong, I enjoy working on the computers, but when we get this close to a test I get real scared. Maybe in the future we could do no computer time the week of tests? I'm really scared about the test. (Mandy, MAT II, Spring 95)

> I think it is important to learn about the computers, but it is more important to learn the math for our tests. . . . I know that my only reason for being in class and at school is not to learn test material, but since the tests are what make up my grades and [since] people do not give me a job interview asking me what I learned in college but look at my grades to determine how well I learned it, I think it is a little more important. . . . It seems that my grades are what got me here, got me the Hope scholarship, kept me from getting other scholarships, will keep me here, and get me a job for my future. (Andrea, MAT II, Spring 95)

Students are naturally concerned with grades. Therefore they may consider that which is assessed to be important, and that which is not assessed to be unimportant or a waste of time. "It is through our assessment that we communicate most clearly to students which activities and learning outcomes we value" (Clarke, 1989, cited in NCTM, 1995).

Computers in the Pre-Service Teachers' Future Careers

From a practical point of view, pre-service teachers were grateful to be able to get some experience with computers. Regardless of their appreciation of the computer as an educational tool, pre-service teachers were aware that "everything is turning to computers these days and it [sic] is something everyone should get familiar with" (Gayle, MAT I, Spring 95). They realized that, as future teachers, they needed to become computer literate. One pre-service teacher wrote, "I am truly computer illiterate and need all of the experience I can get. I know computers are and will be very important in the teaching profession and I want to get started on them as soon as possible" (Christine, MAT II, Fall 94). Hannah (MAT II, Winter 95) commented on her own computer knowledge in relation to the knowledge of her future students: "Math II seems to be more of a

computer oriented class. Maybe this is because kids know more about computers and the teachers need to be updated."

Like Hannah, the pre-service teachers realized that many of their future students were likely to have more experience, particularly in the form of having played games. This experience might make the students more amenable to exploring mathematics by using the computer. Martha (MAT I, Spring 95) commented, "Today most children love video games and of course television. Computers are a combination of the two." Eric (MAT I, Spring 95) saw the microworlds as games and the explorations with them as playful: "Computers make learning fun because it almost seems like a game. . . it makes as person want to keep 'playing' with it, and playing is an excellent way to learn." Others realized how specific computer programs could be used as motivational tools in their classrooms: "I think programs like Chance and The Geometer's Sketchpad will be both fun and useful to elementary students. I hope to somehow incorporate computer programs like those into my class" (Diana, MAT II, Spring 95).

Most pre-service teachers appreciated that specific software programs such as a spreadsheet could be helpful for some of the administrative aspects of their careers: "this [program] will be helpful in averaging and graphing tests in the future" (Mary Carroll, MAT II, Winter 95). They appreciated the accuracy, ease, and neatness with which the software produced the desired results.

Occasionally, pre-service teachers doubted that computer skills would be helpful and necessary for their teaching careers because "K-4 students will not be on computers. Most students have to learn math long hand" (Lisa, MAT I, Fall 94). Jenny (MAT II, Spring 95) drew on her mother's experience as a teacher: "My mother, a fifth grade teacher, told me that today's math curriculum is centered on teaching the children how to handle manipulatives." Although Jenny enjoyed the computer sessions and thought they were interesting, she doubted that they would help her learn "how to teach the basics of math to elementary students."

Computers as Tools of Communication

An important aspect of the computer experience in the three MAT II sections was the introduction and use of e-mail. In the Fall 94 group, students who already owned an e-mail

account were encouraged to use it for their weekly reflections. In the Winter 95 and Spring 95 sections, every student was required to sign up for an e-mail account and encouraged to take advantage of the account. The students were not, however, forced to send their weekly reflections electronically. We had to consider students who had no easy access to a computer facility because they were either commuting or had to care for small children: "I have a 3 month old baby and . . . it's almost impossible for me to stay after class and do a problem on the computer" (Cathy, MAT II, Spring 95).

Format. The most obvious difference between hand-written reflections and reflections sent electronically was the format. The hand-written reflections were composed like assignments, with the student's name and the date in the upper right hand corner and often with a title such as "Weekly reflection" or "Reflection # 5." The e-mail reflections, on the other hand, were often composed as letters. The students used various salutations, some formal ("Dear. Dr. Wiegel:"), some informal ("Hi!"). Most students also ended the reflection with a complimentary closure, again some formal ("Sincerely, Gary"), others less formal ("Bye," "See ya in class," or "Have a nice weekend"). A few students had experimented with the signature feature of the software and signed off with a statement such as "Teaching. An Art & A Science" (Shannon, MAT II, Spring 95) or "The Truth is Out There" (Anne, MAT II, Fall 94).

Personal comments. In addition to the more personal style of the weekly reflections, students who communicated over e-mail also included more personal comments than students who wrote the reflections by hand. Some shared that they were happy to be able to communicate with their boyfriends in a different university over e-mail, others talked about their weekends or personal events. Frequently, they asked about our well being or wished us a pleasant weekend. One e-mail chat led to an invitation to a concert given by a choir in which one of the students was involved. Through the e-mail conversations, we learned more about our students than what we would have learned during class or office hours. Conversely, the students came to see us as persons rather than just as a instructors of a particular course.

Pedagogical discussions. With some of the students, longer pedagogical discussions about teaching and learning evolved. Andrea's comments about the importance of grades were the result of such a discussion. A class discussion about the students' perception of a "fair" teacher continued over e-mail for some time. Susan (MAT II, Winter 95) once asked about a particular textbook, and that question initiated a discussion about the difference between American and German school systems, teaching methods, and textbooks. She reflected on this conversation at the end of the course: "I have enjoyed our e-mail chats - you have given me a lot to think about in terms of how I will eventually teach students."

Most importantly, the convenience of electronic communication gave the students almost unlimited access to the instructor. It was easy to answer almost all of the e-mail reflections and messages. Even if a student's suggestion was not followed, the students knew that their questions, opinions, and reflections were taken seriously. Sheila (MAT II, Winter 95) expressed her appreciation in her final reflection: "I think e-mail is really good to have. It helped us keep in touch with you in at all times. It really helped me a lot. If I had a question, I could ask you over e-mail and you would get back to me the next day. It was very helpful."

In conclusion, electronic communication can change the relationship between the instructor and the students. The division between the roles of instructor and student become blurred, and the interactions are more personal.

SUMMARY AND DISCUSSION

Overall, the incorporation of computer activities into the mathematics content courses, in addition to lectures and manipulative labs, was a positive experience for the pre-service teachers as well as for the instructors. Students were grateful for the opportunity to become familiar with and operate software programs they might encounter in their professional lives as teachers. Although many students felt insecure about their computer skills, they felt confident that, given time and opportunity, they would overcome their initial hesitation. We did not feel that computer anxiety added to the apprehension many students already felt toward mathematics. On the contrary, the computer sessions contributed to a more relaxed classroom atmosphere and served, for some

students, as an incentive for consistent class attendance. In addition, the ease of electronic communication led to extended and more personal teacher-student interactions. From the instructors' and the pre-service teachers' points of view, the computer activities helped students develop a deeper understanding of the mathematical concepts taught. In that, we achieved our primary goal for introducing the computers.

There are, however, two issues that need further elaboration. The first issue concerns the trade-off in time. Students have to acquire some knowledge of the basic operation of the computer before they can use it for mathematical explorations. They must learn how to operate the computer, find and manipulate programs, and learn enough about trouble-shooting so that their work does not grind to a stop every time the computer does not behave as expected. Although some computer skills can be learned in the context of a mathematical task, too much attention to the basic mechanical operation of the computer detracts from the mathematics content on which the students should be focusing. In addition, mathematical explorations, whether on the computer or with some other medium, require time. In order to provide that time, we had to decide which topics seemed to be most relevant for the pre-service teachers. The conflict between depth of understanding and breadth of study is not unique, but was heightened by our introduction of a new medium.

The second unresolved issue is that of grading. Our decision not to grade the computer activities per se nor to include computer items on the test led to pressure from some students to drop the computer labs. They felt that doing activities on which they would not be graded was a waste of time, particularly if there was a test pending. Again, the conflict between learning for a test and learning for understanding is not unique to the inclusion of computers into a particular course. This conflict has to be negotiated with every new group of students. Alternate ways of assessment such as group projects or portfolios might provide ways to respond to the pre-service teachers' need for external reinforcement without necessarily increasing their test anxiety.

We feel that our students' positive affective responses to the inclusion of computer activities is important. We are aware that when our students finish our courses they will forget some, and

perhaps over time, most of the mathematics they have encountered in our classes. Nor are they likely to use the same computers or computer programs that were presented in the classes. However, if our students have had positive experiences with mathematics they will be more likely to anticipate future encounters with mathematics with pleasure. They will also be more likely to paint a favorable picture of mathematics for their students, a picture that shows that "math is not just solving equations and formulas. By working on the computers in the course, I have now become aware that math is all around us!" (Ethan, MAT II, Winter 95).

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